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(54) **BLADE DRIVE DEVICE AND OPTICAL INSTRUMENT**

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G03B 9/36 (2013.01)
USPC **396/469**

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CPC G03B 9/10; H02N 2/0055; H02N 2/006
USPC 396/463, 469
See application file for complete search history.

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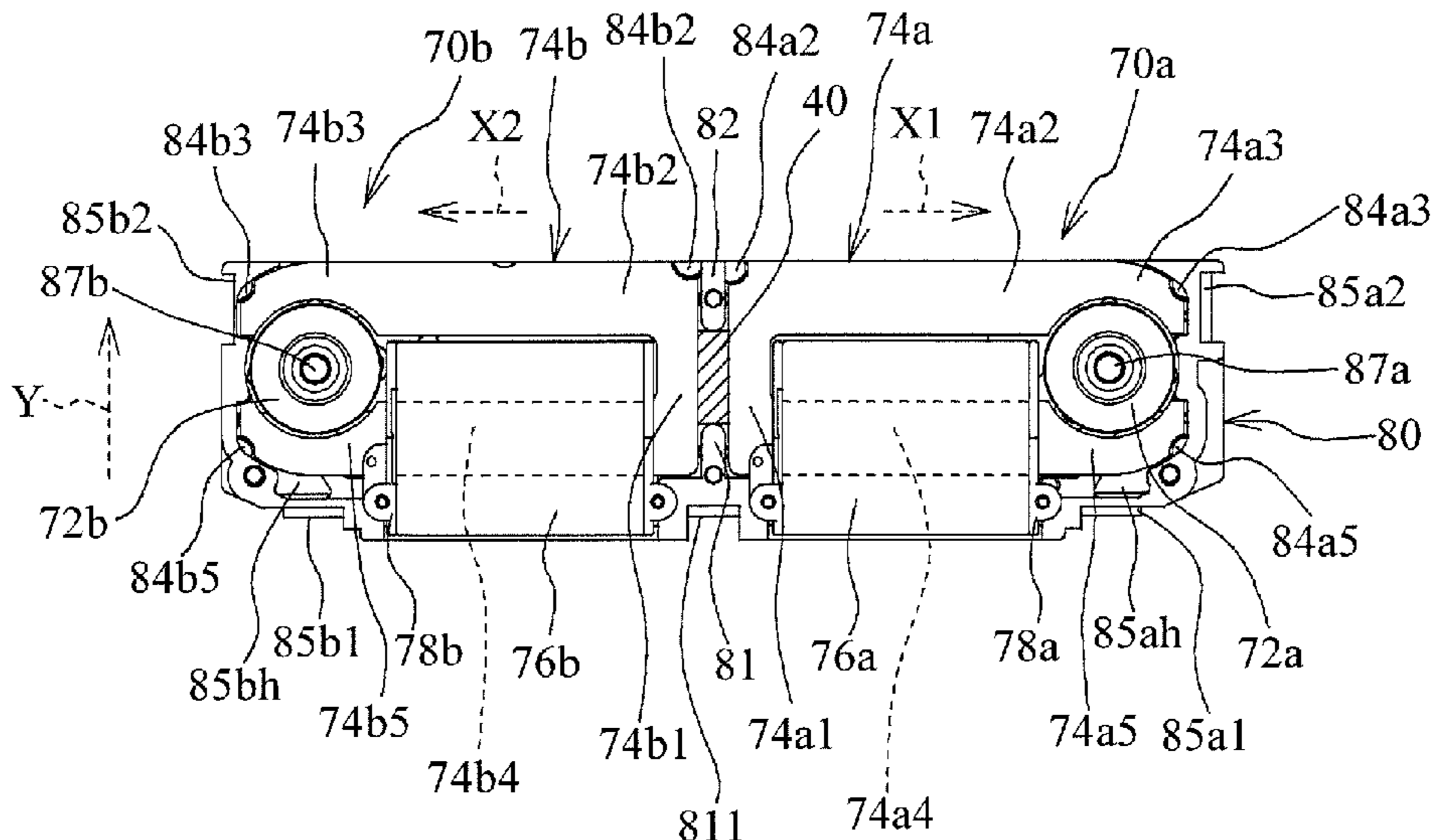
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(57) **ABSTRACT**

A blade drive device includes: a board including an opening; a blade movable between a position receding from the opening and a position covering at least a portion of the opening; a first actuator including a first rotor rotatable about a first axis and a first stator, and being capable of driving the blade; a second actuator including a second rotor rotatable about a second axis and a second stator, and being capable of driving the blade; first and second positioning portions respectively positioning the first and second actuators; and a first biasing member respectively biasing the first and second actuators toward the first and second positioning portions.

11 Claims, 4 Drawing Sheets



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FIG. 2

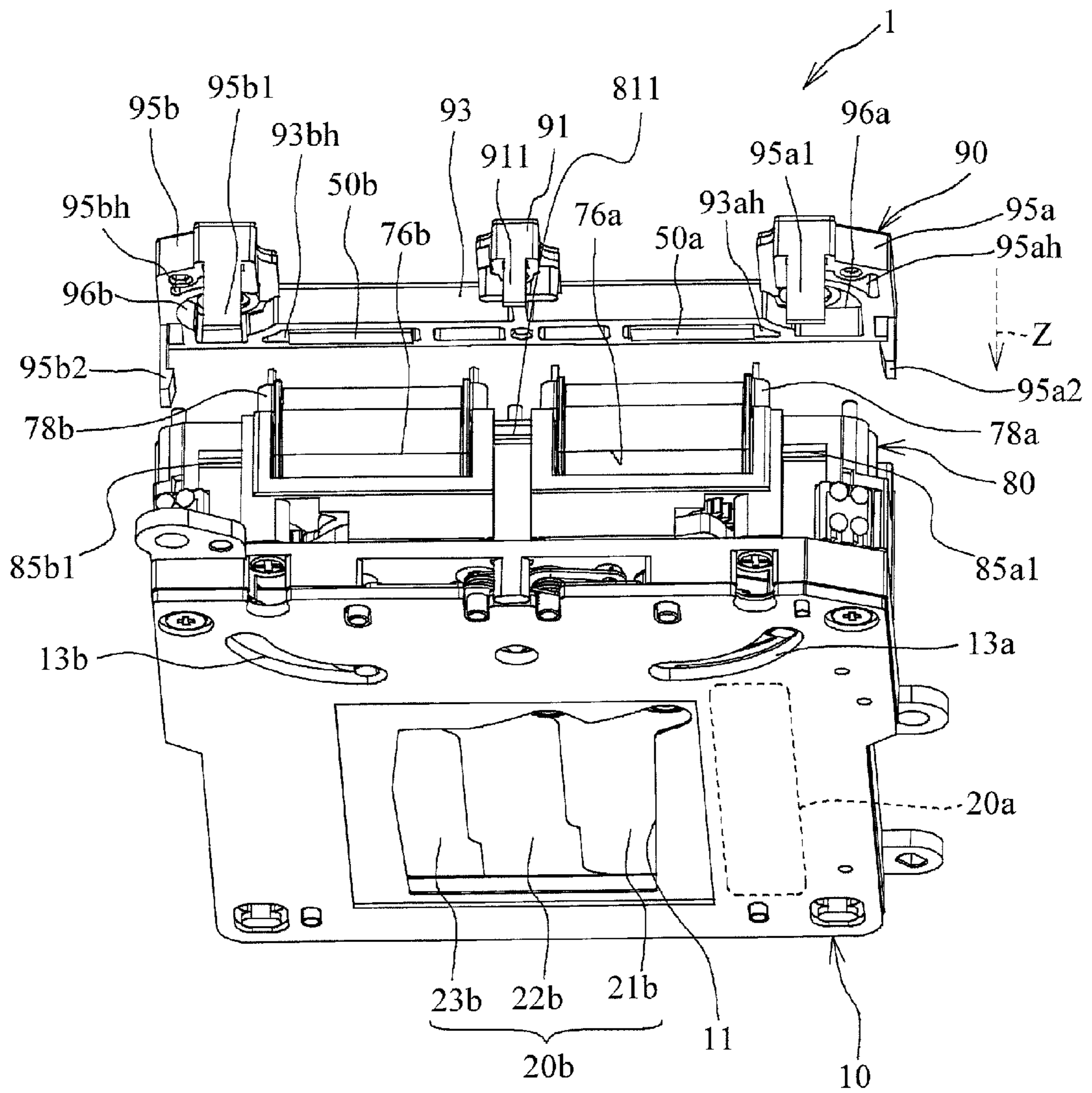


FIG. 3

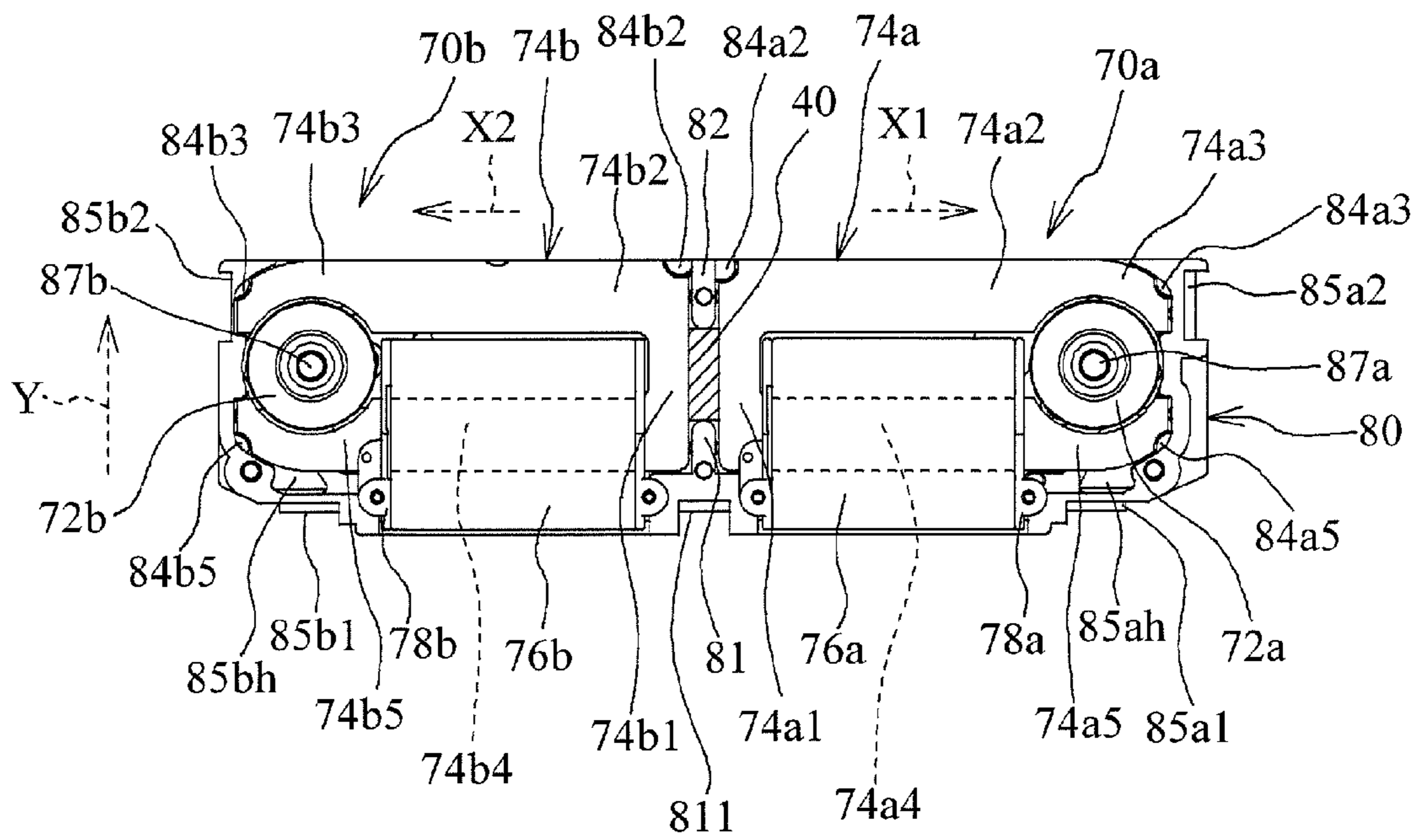
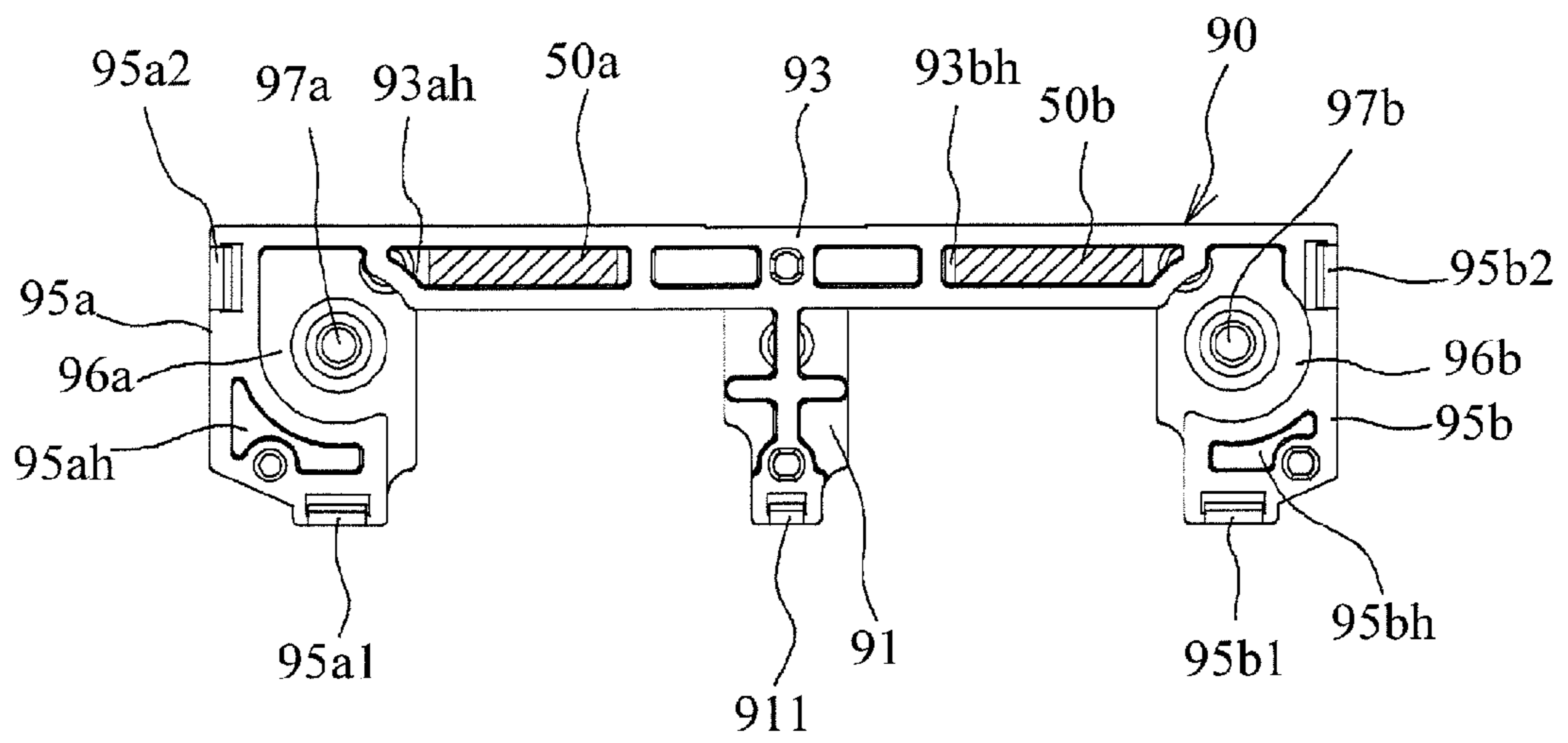


FIG. 4



1

BLADE DRIVE DEVICE AND OPTICAL INSTRUMENT

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation of and claims priority to International Patent Application No. PCT/JP2012/052366 filed on Feb. 2, 2012, which claims priority to Japanese Patent Application No. 2011-130548 filed on Jun. 10, 2011, subject matter of these patent documents is incorporated by reference herein in its entirety.

BACKGROUND

(i) Technical Field

The present invention relates to blade drive devices and optical instruments.

(ii) Related Art

There is a blade drive device equipped with: a board including an opening; a blade opening and closing the opening, and an actuator driving the blade. The actuator is positioned by positioning portions which are integrally or separately provided in the board. It can be considered that a biasing member is provided for biasing the actuator toward the positioning portions in order to stabilize operating characteristics of the blade. Japanese Unexamined Patent Application Publication No. 2010-256473 discloses a blade drive device equipped with a biasing member for biasing a stator of an actuator.

There is the blade drive device equipped with plural actuators. In such a case, when biasing members are respectively provided for plural actuators, the blade drive device might be increased in size.

SUMMARY

It is thus object of the present invention to provide a blade drive device suppressing an increase in the size thereof, suppressing a variation in operating characteristics of a blade, and including a plurality of actuators, and an optical instrument having the same.

According to an aspect of the present invention, there is provided a blade drive device including: a board including an opening; a blade movable between a position receding from the opening and a position covering at least a portion of the opening; a first actuator including a first rotor rotatable about a first axis and a first stator, and being capable of driving the blade; a second actuator including a second rotor rotatable about a second axis and a second stator, and being capable of driving the blade; first and second positioning portions respectively positioning the first and second actuators; and a first biasing member respectively biasing the first and second actuators toward the first and second positioning portions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a blade drive device according to the present embodiment;

FIG. 2 is a perspective view of the blade drive device according to the present embodiment;

FIG. 3 is an explanatory view of a holder; and

FIG. 4 is an explanatory view of a cover.

DETAILED DESCRIPTION

FIGS. 1 and 2 are perspective views of a blade drive device 1 according to the present embodiment. The blade drive

2

device 1 is also referred to as a focal plane shutter. The blade drive device 1 is employed in an optical instrument such as a digital camera, a still camera, or a video camera. The blade drive device 1 includes a board 10, a leading blade 20a, a trailing blade 20b, actuators 70a and 70b, a holder 80, and a cover 90. The leading blade 20a is an example of first blades. The trailing blade 20b is an example of second blades. The board 10 includes the opening 11. The leading blade 20a and the trailing blade 20b open and close this opening 11. The actuators 70a and 70b respectively drive the leading blade 20a and the trailing blade 20b. The actuators 70a and 70b are an example of first and second actuators, respectively. The holder 80 supports the actuators 70a and 70b and is secured to the board 10. The holder 80 is an example of a support member. The cover 90 is secured to the holder 80 so as to cover at least a portion of the actuators 70a and 70b supported by the holder 80.

The leading blade 20a and the trailing blade 20b each include plural blades. Specifically, the plural blades included in the leading blade 20a are connected to two arms that are rotatably supported by the board 10 in the parallel-linkage manner. The trailing blade 20b has the same arrangement. The leading blade 20a recedes from the opening 11 in a state where plural blades overlap one another, and covers the opening 11 in a state where blades expand. The trailing blade 20b has the same arrangement. FIGS. 1 and 2 illustrate a state where the plural blades included in the leading blade 20a overlap one another and recedes from the opening 11 and the plural blades 21b, 22b, and 23b included in the trailing blade 20b expand and cover the opening 11.

The actuator 70a includes: a rotor 72a rotatably supported by the holder 80; a stator 74a excited to generate magnetic force between the stator 74a and the rotor 72a, and a coil 76a for exciting the stator 74a. The rotor 72a is a permanent magnet that is energized to have different polarities in the circumferential direction. The rotation of the rotor 72a is transmitted to the leading blade 20a through a member, not illustrated. The rotation of the rotor 72a drives the leading blade 20a. The actuator 70b has the same arrangement. The rotation of the rotor 72b drives the trailing blade 20b. Additionally, FIG. 2 illustrates escape slots 13a and 13b formed in the board 10. The escape slot 13a is provided for permitting the movement of a drive pin transmitting the rotation of the rotor 72a to the leading blade 20a. The escape slot 13b has the same arrangement.

The holder 80 supporting the actuators 70a and 70b is secured to the board 10. The holder 80 is provided with engaging claws 811, 85a1, 85a2, 85b1, and 85b2 (Not illustrated in FIGS. 1 and 2, but shown in FIG. 3). The cover 90 is provided with plural engaging claws 911, 95a1, 95a2, 95b1, and 95b2. These claws engage with each other, so the holder 80 and the cover 90 are secured to each other. The holder 80 and the cover 90 are made of a synthetic resin. FIGS. 1 and 2 illustrate a state before the holder 80 is assembled with the cover 90. Additionally, after the holder 80 is assembled with the cover 90, the cover 90 is secured with a flexible printed circuit board that is electrically connected with the coils 76a and 76b.

FIG. 3 is an explanatory view of the holder 80. FIG. 3 is the view when viewed from the front side of the holder 80. The holder 80 is formed with spindles 87a and 87b rotatably supporting the rotors 72a and 72b, respectively. The spindles 87a and 87b extend in the direction perpendicular to a plane parallel to the board 10. The spindles 87a and 87b are parallel to each other. The spindles 87a and 87b are an example of first and second axes.

The stators **74a** and **74b** are arranged on the holder **80**. The stator **74a** includes: a base portion **74a1** extending in a predetermined direction; leg portions **74a2** and **74a4** respectively extending from both ends of the base portion **74a1** in the direction perpendicular to the base portion **74a1**; a magnetic pole portion **74a3** formed at an end of the leg portion **74a2**, and a magnetic pole portion **74a5** formed at an end of the leg portion **74a4**. The leg portion **74a4** is assembled with a coil bobbin **78a** around which the coil **76a** is wound. The magnetic pole portions **74a3** and **74a5** face the rotor **72a**. The energization of the coil **76a** excites the magnetic pole portions **74a3** and **74a5** to respectively generate different polarities. This generates the magnetic force between the magnetic pole portions **74a3** and **74a5** and the rotor **72a**, so the rotor **72a** rotates. Likewise, the stator **74b** includes a base portion **74b1**, leg portions **74b2** and **74b4**, and magnetic pole portions **74b3** and **74b5**. The energization of the coil **76b** rotates the rotor **72b**.

The actuators **70a** and **70b** are arranged on the holder **80** in such a manner that the base portion **74a1** of the stator **74a** faces the base portion **74b1** of the stator **74b**. Specifically, the stators **74a** and **74b** are arranged in the direction perpendicular to the spindles **87a** and **87b**. The holder **80** is provided with partition walls **81** and **82** separating the base portion **74a1** of the stator **74a** from the base portion **74b1** of the stator **74b**. The partition walls **81** and **82** prevent the stators **74a** and **74b** from being brought into contact with each other.

The holder **80** is formed with positioning portions **84a3** and **84a5** which are respectively abutable with the magnetic pole portions **74a3** and **74a5** of the stator **74a**. Further, the holder **80** is formed with a positioning portion **84a2** abutable with the base portion **74a1**. The positioning portions **84a2**, **84a3**, and **84a5** each have a semicircular column shape. When the holder **80** is viewed from the front side as illustrated in FIG. 3, these positioning portions **84a2**, **84a3**, and **84a5** protrude toward the stator **74a**. Portions of the stator **74a** with which these positioning portions are abutable are recessed in such a manner to correspond to the shapes thereof. The actuator **70a** is positioned at a predetermined position by these positioning portions **84a2**, **84a3**, and **84a5**. Likewise, the holder **80** is provided with positioning portions **84b2**, **84b3**, and **84b5** with which the base portion **74b1** and the magnetic pole portions **74b3** and **74b5** are respectively abutable. Portions of the stator **74b** with which these positioning portions are abutable are recessed to correspond to the shapes thereof. The actuator **70b** is positioned at a predetermined position by these positioning portions **84b2**, **84b3**, and **84b5**.

A biasing member **40** is arranged between the stators **74a** and **74b**. Specifically, the biasing member **40** is arranged between the base portion **74a1** of the stator **74a** and the base portion **74b1** of the stator **74b**. The biasing member **40** is an example of a first biasing member. In FIG. 3, the biasing member **40** is illustrated by hatched lines. The space for accommodating the biasing member **40** is defined between the partition walls **81** and **82**. The biasing member **40** is arranged in this space. The biasing member **40** is a rubber, but it may be a foamed member such as a sponge.

In the state illustrated in FIG. 3, the biasing member **40** biases the stator **74a** in the direction X1 and the stator **74b** in the direction X2. Herein, the directions X1 and X2 are the plane direction parallel to the board **10**. The directions X1 and X2 are opposite to each other. Thus, the biasing member **40** biases the stator **74a** toward the positioning portions **84a3** and **84a5**, and biases the stator **74b** toward the positioning portions **84b3** and **84b5**. In other words, the biasing member **40** biases the actuator **70a** toward the positioning portions **84a3** and **84a5** and the actuator **70b** toward the positioning portions

84b3 and **84b5**. Also, the biasing member **40** biases the stators **74a** and **74b** in the direction perpendicular to the spindles **87a** and **87b**. The positioning portions **84a3** and **84a5** are an example of a first positioning portion. The positioning portions **84b3** and **84b5** are an example of a second positioning portion.

As for an order of assembling the stator **74a** to the holder **80**, after the stators **74a** and **74b** are assembled to the holder **80**, the biasing member **40** is inserted between the stators **74a** and **74b**. Therefore, the stators **74a** and **74b** are biased by the biasing member **40**. Herein, there are clearances between the stator **74a** and the positioning portions **84a2**, **84a3**, and **84a5** in order to facilitate assembling the stator **74a** to the holder **80**. If there is no clearance, it might be difficult to assemble the stator **74a** to the holder **80** because of abutment of the stator **74a** with the positioning portion **84a2** or the like. Further, dust might be generated by shaving the positioning portion **84a2** or the like.

However, after the stator **74a** is assembled to the holder **80**, these clearances cause a variation in operating characteristics of the blade driven by the actuator **70a**. As mentioned above, in the actuator **70a**, the energization of the coil **76a** excites the magnetic pole portions **74a3** and **74a5** to respectively generate different polarities. This generates the magnetic force between the magnetic pole portions **74a3** and **74a5** and the rotor **72a**, which rotates the rotor **72a**. Herein, since there are the clearances between the stator **74a** and the positioning portions **84a2**, **84a3**, and **84a5**, this might generate a variation in the positional relationship between the magnetic pole portions **74a3** and **74a5** and the rotor **72a**. The relative positional displacement of the stator **74a** to the rotor **72a** might cause a variation in characteristics of the magnetic force exerted between the rotor **72a** and the stator **74a**. This might cause a variation in rotational characteristics of the rotor **72a**. Specifically, this might cause a variation in operating characteristics such as response speed or torque characteristics of the actuator **70a**. Further, this might cause a variation in operating characteristics such as response speed or operating speed of the leading blade **20a** driven by the actuator **70a**. This might be applicable to the stator **74b**. This might cause the variations in operating characteristics of the leading blade **20a** and the trailing blade **20b**. In the blade drive device **1** according to the present embodiment, the biasing member **40** biases the stators **74a** and **74b** toward the positioning portions **84a3** and **84a5** and the positioning portions **84b3** and **84b5** in the opposite directions, respectively. It is thus possible to suppress the relative positional displacement of the stator **74a** and **74b** with respect to the rotors **72a** and **72b**, respectively, while the above mentioned clearances are ensured. The positional displacement of the stators **74a** and **74b** is suppressed, thereby suppress the variation in operating characteristics of the actuators **70a** and **70b** of the blade drive device **1**. This suppresses the variation in operating characteristics of the leading blade **20a** and the trailing blade **20b** respectively driven by the actuators **70a** and **70b**. Also, the single biasing member **40** biases two stators **74a** and **74b**, thereby suppressing the space where the biasing member occupies in the holder **80**. This suppresses an increase in the size of the holder **80** and an increase in the size of the blade drive device **1**. Further, the single biasing member **40** biases two stators **74a** and **74b**, thereby reducing the number of the parts.

The biasing member **40** is arranged between the partition walls **81** and **82** separating the stators **74a** and **74b** from each other. Therefore, the biasing member **40** is arranged in such a manner to effectively use the space in the holder **80**, thereby suppressing an increase in the size thereof.

As mentioned above, the biasing member **40** biases the stator **74a** only in the direction X1. However, as illustrated in FIG. 3, the positioning portions **84a3** and **84a5** each have a column shape, and the portions of the stator **74a** with which these positioning portions **84a3** and **84a5** are abutable are recessed in such a manner to correspond to the shapes thereof. Therefore, the stator **74a** is biased in the direction X1, so the positioning portions **84a3** and **84a5** also define the position of the stator **74a** in the direction Y perpendicular to the direction X1. Likewise, the stator **74b** is positionally defined in the directions X2 and Y. Therefore, the stators **74a** and **74b** are positionally defined in the plane direction by the biasing member **40** and the positioning portions **84a3**, **84a5**, **84b3**, and **84b5**.

FIG. 4 is an explanatory view of the cover **90**. FIG. 4 illustrates the cover **90** facing the holder **80** when viewed from the holder **80** side in a state where the holder **80** is assembled with the cover **90**. As illustrated in FIG. 4, the cover **90** includes: a base portion **91** extending in a predetermined direction; an extending portion **93** extending in the direction intersecting the base portion **91**; and rotor cover portions **95a** and **95b** respectively formed at both ends of the extending portion **93**. The extending portion **93** extends in such a direction as to move the leading blade **20a** and the trailing blade **20b**. The base portion **91** is positioned at the substantial center of the extending portion **93** and extends in the direction perpendicular thereto. The rotor cover portions **95a** and **95b** are formed with fitting holes **97a** and **97b** into which the spindles **87a** and **87b** are fitted, respectively. The rotor cover portions **95a** and **95b** respectively cover the rotors **72a** and **72b**. The base portion **91**, the extending portion **93**, and the rotor cover portions **95a** and **95b** are provided with holes into which plural pins provided in the holder **80** are fitted. When the cover **90** is secured to the holder **80**, the plural pins formed in the holder **80** fit into the plural holes formed in the cover **90**, respectively.

The extending portion **93** is formed with lightening grooves **93ah** and **93bh** extending longitudinally. The biasing members **50a** and **50b** are inserted into the lightening grooves **93ah** and **93bh**, respectively. The lightening grooves **93ah** and **93bh** do not penetrate the extending portion **93** and each have a oblong hole shape with a bottom. The biasing members **50a** and **50b** are rubbers, but may be sponges that are foamed members. In FIG. 4, the biasing members **50a** and **50b** are illustrated by hatched lines. As illustrated in FIG. 2, the biasing members **50a** and **50b** slightly protrude toward the holder **80** from the bottom surface of the cover **90** facing the holder **80**.

In the state where the holder **80** is assembled to the cover **90**, the biasing members **50a** and **50b** bias the stators **74a** and **74b** in the direction Z, respectively. The direction Z is the direction of the perpendicular line of the plane parallel to the board **10**, and is perpendicular to the directions X1, X2, and Y. In other words, the direction Z is the direction in which the spindles **87a** and **87b** rotatably supporting the rotors **72a** and **72b**, respectively, extend. Also, the biasing members **50a** and **50b** respectively bias the stators **74a** and **74b** toward the holder **80**. Specifically, the biasing members **50a** and **50b** abut with and bias the leg portion **74a2** of the stator **74a** and the leg portion **74b2** of the stator **74b**, respectively. The biasing members **50a** and **50b** held by the cover **90** are an example of a second biasing member. Herein, the direction in which the biasing member **40** biases the stators **74a** and **74b** is perpendicular to the direction in which the biasing members **50a** and **50b** bias the stators **74a** and **74b**. In other words, the direction in which the first biasing member biases the first and second

actuators is perpendicular to the direction in which the second biasing member biases the first and second actuators.

The biasing members **50a** and **50b** respectively bias the stators **74a** and **74b** in the state where the holder **80** is assembled with the cover **90**, so the stators **74a** and **74b** are pushed toward the holder **80** and are positionally defined in the direction Z. This defines the positions of the stators **74a** and **74b** in the direction Z. As mentioned above, the second biasing members function as defining the positions of the stators **74a** and **74b** in the direction Z.

As mentioned above, the position of the stator **74a** are defined in the directions X, Y, and Z by the biasing members **40** and **50a**. It is thus possible to suitably suppress the relative positional displacement of the stator **74a** to the rotor **72a**. This suppresses the variation in characteristics of the magnetic force exerted between the rotor **72a** and the stator **74a**. It is therefore possible to suppress the variation in rotational characteristics of the rotor **72a**. This is applicable to the rotor **72b**. This makes it possible to suppress the variation in operating characteristics of the leading blade **20a** and the trailing blade **20b**.

In the present embodiment, the stator **74a** of the actuator **70a** includes plural stators that have the same shape and overlap each other in the direction Z in which the spindle **87a** extends. This is because, in a case where one plate is processed to make a stator having a required thickness for ensuring desired output, a desired shape accuracy might not be ensured. In the actuator **70a** of the blade drive device **1** according to the present embodiment, two pieces included in the stator **74a** overlap each other in the direction of the spindle **87a**. The stator **74b** has the same arrangement. Herein, as mentioned above, the position of the stator **74a** is defined in the directions X, Y, and Z by the biasing members **40** and **50a**. In this case, since the biasing member **50a** causes two pieces of the stator **74a** to come into close contact with each other in the direction Z, the biasing member **50a** functions as reducing the loss of the magnetic flux passing through the stator **74a** and also functions as suppressing a variation in output characteristics of the actuator **70a**. The actuator **70b** and the stator **74b** have the same arrangements. Thus, there can be provided the blade drive device that suppresses the variation in the operating characteristics of the leading blade **20a** and the trailing blade **20b**, and that suppresses the variation in output characteristics of the actuator, even if the stator includes the plural plates.

Also, in a case where the plural pieces of the stator are used like the actuator in the present embodiment, the plural pieces of the stator might resonate to make a noise. In the present embodiment, the plural pieces of the stator are positionally defined in the directions X, Y, and Z by the biasing members. This can prevent the stator from vibrating, thereby suppressing the resonance noise of the actuator.

Additionally, it can be considered that the position of the stator **74a** is defined by bonding the stator **74a** to the holder **80**. However, in this case, the positional adjustment of the stator **74a** and the process of applying the adhesive bond might degrade the assembling workability of the blade drive device **1**. Further, the adhesive bond applied to the holder **80** might leak to an undesired area. Also, it can be considered that the stator **74a** is secured to the holder **80** by a screw. In this case, an operator has to tighten the screw, so that the assembling workability of the blade drive device **1** might also be degraded. Also, the stator **74a** has to be provided with a hole through which the screw penetrates, so that the space cannot be used with efficiency, and dust might be generated. Further, the processing of the stator **74a** might be complicated, so that the manufacturing cost of the stator **74a** might increase. In the

blade drive device **1** according to the present embodiment, such above problems are suppressed by employing the biasing members **40**, **50a**, and **50b**.

The lightening grooves **93ah** and **93bh** illustrated in FIGS. **2** and **4** are provided for making the thickness of the cover **90** uniform. The cover **90** holds the biasing members **50a** and **50b** by using the lightening grooves **93ah** and **93bh**, thereby suppressing an increase in the size of the cover **90**.

Additionally, as illustrated in FIGS. **3** and **1**, the holder **80** is formed with cutout portions **85ah** and **85bh** near the magnetic pole portions **74a5** and **74b5**, respectively. Thus, the space is defined between the cutout portion **85ah** and the magnetic pole portion **74a5**. Likewise, the space is defined between the cutout portion **85bh** and the magnetic pole portion **74b5**. In addition to the biasing member **40**, other biasing members may be inserted between the cutout portion **85ah** and the magnetic pole portion **74a5** and between the cutout portion **85bh** and the magnetic pole portion **74b5**, respectively. The stators **74a** and **74b** are suitably biased in the direction Y by these biasing members. The direction Y is perpendicular to the spindles **87a** and **87b** and is perpendicular to the directions X1 and X2 in which the biasing member **40** respectively biases the stators **74a** and **74b**. Specifically, the biasing member inserted into the cutout portion **85ah** biases the stator **74a** toward the positioning portion **84a3**. The biasing member inserted into the cutout portion **85bh** biases the stator **74b** toward the positioning portion **84b3**. The biasing members inserted into the cutout portions **85ah** and **85bh** and held by the holder **80** are an example of a third biasing member. Here, the directions where the biasing member **40** as the first biasing member biases the stators **74a** and **74b**, the direction where the biasing members **50a** and **50b** as the second biasing member bias the stators **74a** and **74b**, and the direction where the above third biasing members inserted into the cutout portions **85ah** and **85bh** bias the stators **74a** and **74b** are perpendicular to one another. It is thus possible to stably define the positions of the stators **74a** and **74b**.

Also, as illustrated in FIG. **4**, the rotor cover portions **95a** and **95b** are formed with escape portions **96a** and **96b** for receiving the rotors **72a** and **72b**, respectively. Further, the rotor cover portions **95a** and **95b** are formed with lightening grooves **95ah** and **95bh**, respectively. The lightening grooves **95ah** and **95bh** do not respectively penetrate through the rotor cover portions **95a** and **95b**, and each have a hole shape with a bottom. The lightening grooves **95ah** and **95bh** are respectively formed near the escape portions **96a** and **96b**. Biasing members may be respectively inserted into the lightening grooves **95ah** and **95bh**. Therefore, the biasing members, which are inserted into the lightening grooves **95ah** and **95bh** in the state where the cover **90** is secured to the holder **80**, respectively bias the magnetic pole portion **74a5** of the stator **74a** and the magnetic pole portion **74b5** of the stator **74b** in the direction Z. The above biasing members respectively inserted into the lightening grooves **95ah** and **95bh** and held by the cover **90** are an example of the second biasing member, and the above biasing members function as defining the positions of the stators **74a** and **74b** in the direction Z. This can also define the positions of the stators **74a** and **74b**.

The biasing member inserted into the cutout portion **85ah** of the holder **80** and the biasing member inserted into the lightening groove **95ah** of the cover **90** abut with the magnetic pole portion **74a5** of the stator **74a**. This prevents the magnetic pole portion **74a5** from rattling in the direction Z. Herein, the magnetic pole portion **74a5** faces the rotor **72a** rotatably supported. Thus, the vibration caused by the rotation of the rotor **72a** tends to be transmitted to the magnetic pole portion **74a5**. However, the biasing members respec-

tively inserted into the cutout portion **85ah** and the lightening groove **95ah** abut with the magnetic pole portion **74a5** to define the position thereof. The magnetic pole portion **74a5** near the rotor **72a** is positionally defined in such a manner, thereby effectively suppressing the relative positional displacement of the stator **74a** to the rotor **72a**. Likewise, biasing members respectively inserted into the cutout portion **85bh** of the holder **80** and the lightening groove **95bh** of the cover **90** effectively suppress the relative positional displacement of the stator **74b** to the rotor **72b**. This suppresses the variation in the operating characteristics of the blade driven by the actuators **70a** and **70b**.

Additionally, a biasing member may be inserted into the lightening groove **95ah**, instead of inserting the biasing member **50a** into the lightening groove **93ah**. A biasing member may be further inserted into the lightening groove **95ah**, in addition to inserting the biasing member **50a** into the lightening groove **93ah**. Likewise, a biasing member may be inserted into the lightening groove **95bh** instead of inserting the biasing member **50b** into the lightening groove **93bh**. A biasing member may be further inserted into the lightening groove **95bh** in addition to inserting the biasing member **50b** into the lightening groove **93bh**.

While the exemplary embodiments of the present invention have been illustrated in detail, the present invention is not limited to the above-mentioned embodiments, and other embodiments, variations and modifications may be made without departing from the scope of the present invention.

In the above present embodiment, the focal plane shutter has been described as one example of the blade drive device. However, the blade drive device may not be the focal plane shutter. Also, a blade is not limited to one linearly moving. A blade may rotate about a predetermined position as a fulcrum. Also, a blade may be a small diaphragm blade which reduces an opening of a board to a desired size. Also, the only single blade may be driven by a single actuator. Also, a blade drive device may be provided with two actuators for driving the only single blade.

In the above embodiment, the biasing members **50a** and **50b** are provided at the cover **90** side. However, the present invention is not limited to this. Biasing members respectively biasing the stators **74a** and **74b** toward the cover **90** may be provided at the holder **80** side.

At least one of the biasing members **40**, **50a**, and **50b** may be a spring made of a non-magnetic material. For example, at least one of the biasing members **40**, **50a**, and **50b** may be a coil spring or a leaf spring made of a non-magnetic material.

In the above embodiment, the rotor **72a** is separately provided from the spindle **87a** rotatably supporting the rotor **72a**. That is, the spindle **87a** is provided in the holder **80**, and does not rotate. However, the present invention is not limited to this. For example, the rotor **72a** may be rotatably supported by a rotational shaft integrally provided therewith.

In the above embodiment, the holder **80** supporting the actuators **70a** and **70b** is separately provided from the board **10**. However, the present invention is not limited to this. For example, the board **10** may be provided with support portions for supporting the actuators **70a** and **70b**, instead of providing the holder **80**.

Finally, several aspects of the present invention are summarized as follows.

According to an aspect of the present invention, there is provided a blade drive device including: a board including an opening; a blade movable between a position receding from the opening and a position covering at least a portion of the opening; a first actuator including a first rotor rotatable about a first axis and a first stator, and being capable of driving the

blade; a second actuator including a second rotor rotatable about a second axis and a second stator, and being capable of driving the blade; first and second positioning portions respectively positioning the first and second actuators; and a first biasing member respectively biasing the first and second actuators toward the first and second positioning portions.

The first biasing member respectively biases the first and second actuators toward the first and second positioning portions, thereby suppressing an increase in the size and suppressing a variation in operating characteristics of the blade.

According to another aspect of the present invention, there is provided an optical instrument having the above blade drive device.

What is claimed is:

1. A blade drive device, comprising:
 - a board including an opening;
 - a blade movable between a position receding from the opening and a position covering at least a portion of the opening;
 - a first actuator including a first rotor rotatable about a first axis and a first stator, and being capable of driving the blade;
 - a second actuator including a second rotor rotatable about a second axis and a second stator, and being capable of driving the blade;
 - first and second positioning portions respectively positioning the first and second actuators; and
 - a first biasing member respectively biasing the first and second actuators toward the first and second positioning portions,
 - the first and second positioning portions respectively positioning the first and second stators, and
 - the first biasing member respectively biasing the first and second stators toward the first and second positioning portions.
2. The blade drive device of claim 1, wherein the first biasing member is arranged between the first and second stators, and biases the first and second stators in opposite directions.
3. The blade drive device of claim 1, wherein
 - the first and second axes are parallel to each other,
 - the first and second stators are arranged in a direction perpendicular to the first and second axes, and
 - the first biasing member biases the first and second stators in the direction perpendicular to the first and second axes.
4. The blade drive device of claim 1, comprising:
 - a support portion supporting the first and second actuators and provided in the board, and
 - a second biasing member biasing the first and second actuators toward the support portion in a direction perpendicular to the direction in which the first biasing member biases the first and second actuators.
5. The blade drive device of claim 1, comprising:
 - a support portion supporting the first and second actuators and provided in the board;

a cover portion secured to the support portion and covering the first and second actuators, and

a second biasing member biasing the first and second actuators toward the cover portion in a direction perpendicular to the direction in which the first biasing member biases the first and second actuators.

6. The blade drive device of claim 1, comprising a third biasing member biasing the first and second actuators in a direction perpendicular to the first and second axes and perpendicular to the direction in which the first biasing member biases the first and second actuators,

wherein the support portion holds the third biasing member.

7. The blade drive device of claim 1, wherein the blade includes:

- first blades including a plurality of blades and driven by the first actuator, and
- second blades including a plurality of blades and driven by the second actuator,

the first blades recede from the opening in a state where the first blades overlap each other, and cover the opening in a state where the first blades expand, and

the second blades recede from the opening in a state where the second blades overlap each other, and cover the opening in a state where the second blades expand.

8. The blade drive device of claim 1, wherein the first and second stators each includes a plurality of parts overlapping each other in a direction of the first and second axes.

9. The blade drive device of claim 1, wherein the first biasing member is at least one of a rubber, a foamed member, and a spring member made of a non-magnetic material.

10. The blade drive device of claim 4, comprising a cover portion secured to the support portion, covering the first and second actuators, and holding the second biasing member.

11. An optical instrument comprising a blade drive device, comprising:

- a board including an opening;
- a blade movable between a position to recede from the opening and a position to cover at least a portion of the opening;

- a first actuator including a first rotor rotatable about a first axis and a first stator, and capable of driving the blade;
- a second actuator including a second rotor rotatable about a second axis and a second stator, and capable of driving the blade;

- first and second positioning portions respectively positioning the first and second actuators; and

- a first biasing member respectively biasing the first and second actuators toward the first and second positioning portions,

- the first and second positioning portions respectively positioning the first and second stators, and

- the first biasing member respectively biasing the first and second stators toward the first and second positioning portions.

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